Have the Noer Facility in Your Backyard

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As some of you know, I got my start in the turfgrass industry when I was fifteen years old. That summer I got a job busing tables at Saz's restaurant during the Wisconsin State Fair. Instead of blowing the money on typical teenage 'necessities', I spent the $500 paycheck on tons of sand, pea gravel, and 4 inch plastic drain tile. The goal was simple, build a USGA spec putting green in my parent's backyard partly because so many told me it couldn't be done.

Over the course of the next three summers my 'A4' putting green project expanded into a chipping course complete with a meandering bentgrass fairway and five sand bunkers. When I look back at it now I realize how much I learned in that backyard. It provided me a turfgrass research facility where I could experiment with different management techniques, products, and ideas without fear of killing grass; a frequent occurrence. In fact, the Primo Maxx GDD studies of my B.S. and M.S. at UW-Madison came directly from questions and ideas I had while working on my backyard putting green.

The goal of this article is not to introduce a new management technique or product but is to explain how to do turfgrass field research in your own backyard (or at your golf course). It can be extremely advantageous to have some kind of research area at your golf course. It provides you the opportunity to test the effectiveness of new products, compatibility between products, evaluate new grass varieties, test different irrigation regimes, and try new equipment or different settings (i.e. mowing heights or aerator tine diameter and spacing).

The research area can also be used to demonstrate a particular management practice to your superiors, green committee, or membership. It can also be a great teaching tool for summer interns or assistant superintendents. In any case a small turfgrass research area can be a great benefit to you and your facility. In this article I'll discuss how to design a basic experiment, set up research plots, and collect and analyze data in a cheap, easy, and hopefully understandable fashion. Even if you have absolutely no intention of doing any research, I hope this article helps you to understand what goes into field research and understand research reports.

Having a research area like my backyard putting green provides you the opportunity to try new management techniques and products without fear of killing grass.

Designing an Experiment

The most important step of experimental design is to develop a central question of problem statement. For example, how well does this fertilizer work, can my greens handle two successive aerations, how can I speed snow mold recovery in the green banks, or how often do I need to apply this plant growth regulator to maintain yield suppression? It isn't difficult to develop these questions because they typically arise throughout the workday. You don't need to formally write out this statement, but keep it in mind as the ultimate goal of the experiment. After you've developed a question, try to anticipate the answer to your question aka develop a hypothesis.

The next step is to actually design the experiment and specifically the treatments (variables) and controls. This is the fun part of research. The variable treatments are the practices that get manipulated during an experiment while the controls are practices that are the same across all treatments in the experiment. The variable treatments should represent a range of possible responses. For example, if the product you are evaluating has a range of application rates test the low, medium, and high rates to see if it is worth the extra cost to use a higher application rate. It is also important to have a non-treated plot for comparison, which is often forgotten but is the most important treatment! All other management practices besides the treatments being studied should be the same across all the treatments. An additional part of experimental design typically neglected by superintendents is replication. Replication is so important because it ensures what you are observing is not a fluke. Here is a hypothetical example of a research question and treatment design:

Question: I have a moss problem on my greens. The hypothetical product 'MossX' can control moss but may also cause burn depending on the application rate. What rate should I use to minimize burn yet still control the moss? Also, is it safe to apply it with my wetting agent?

Treatments: 3 'MossX' application rates – non-treated control, low, and high labeled rates
2 wetting agent rates – none and labeled wetting agent rate

Controls: Same mowing height, fertilizer rate, topdressing rate, irrigation regime for all treatments.

Replication: 3 replicates of each treatment

Total Plots: 18 (3 'MossX' rates x 2 wetting agent rates x 3 replicates)

In this example there are two types of treatments (or factors). One factor is the three 'MossX' application rates and the other factor is the two wetting agent application rates. Therefore there are actually six different treatments (all the 'MossX' rates with or without wetting agent application). This is called a balanced factorial design because each treatment of one factor is applied with each variable of the other factor. Finally all three treatments are replicated three times. This brings the total number of plots required to do this experiment up to 18 (6 treatments x 3 reps). This is one major reason turfgrass researchers have to limit the number of treatments in an experiment. For example, if we wanted to test three 'MossX' rates, two wetting agent rates, at two mowing heights, and at three irrigation regimes replicated three times there would by 108 total plots (3x2x2x3x3=108) and makes for complicated data analysis.

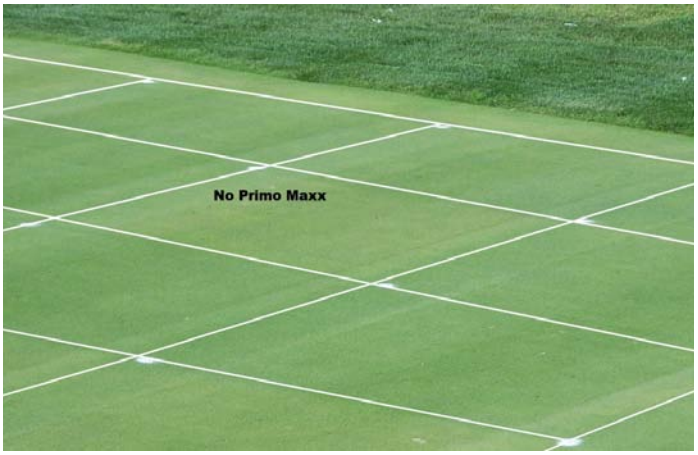
The next step in the design is to decide what you are going to measure and for how long. Sometimes turfgrass researchers measure attributes that require too much expertise, equipment, time, and expense to feasibly do away from a lab or dedicated research facility. That being said, many notable research papers measure responses as simple as turfgrass visual quality, color, or clipping yield. Don't underestimate the importance of simple and careful observation. Ultimately, the responses you decided to measure are dictated by the problem you are trying to understand during that experiment. Some common and easy measurements include:

Turfgrass Visual Quality Rating: Visually rate the turfgrass on a one to nine scale where one equals dead/brown turfgrass and nine is the most perfect turfgrass you could possibly imagine. Generally the value of six represents minimal acceptable quality, and the steps between rating values are half a unit (i.e. 6, 6.5, 7, and 7.5). This rating encompasses all aspects related to turfgrass quality including color, density, uniformity, ect. To help determine the values it is helpful to find the worst and best plot that you can compare the other plots to. For example, if the worst plots looks to be a four and the best an eight all the other plots should have ratings between a four and an eight.

Attribute Specific Ratings: These ratings are more specific than turfgrass quality. Some examples include visual estimation of turfgrass color, density, diseases severity, recovery from topdressing/aeration, or percent disease, weed, or dry spot in a plot. These ratings can be on a similar scale as turfgrass quality (1 to 9) or as a percent (i.e. this plot is covered with 40% localized dry spot).

Quantitative Measurements: While the previous ratings are more qualitative, there are many quantitative measurements that can be easily taken; especially with the explosion of measurement equipment like TDR soil moisture probes. Companies such as Spectrum Technologies have TDR moisture probes, chlorophyll meters to measure grass color, and inferred thermometers to measure how hot the grass gets, which can be used to gather data from research plots. Another quantitative measurement is clipping yield, however, it is difficult to measure because it needs to be collected from a specific area, clippings need to be dried at 140°F for 24 hours, and then weighed on a very accurate scale (a postage scale usually is not good enough).

Laboratory Measurements: Several soil testing labs including the UW Soil and Plant Analysis labs can test many plant and soil properties such as tissue nutrient contents and soil fertility levels which are very useful in research but can be very expensive. For example, if we wanted to see what the nutrient contents were in the 'MossX' experiment (18 plots) and it cost $15 to get that analysis the total cost for one days sampling would be $270.



This shows the importance of a non-treated control and replication. The plot in the center was not treated with Primo Maxx and surrounded by many replicates treated with Primo Maxx (other non-treated replicates are not shown).

Visual observations of turfgrass can provide a great deal of information. I'm recording spring snow mold recovery ratings on plot map.

That said there may be cases where that information may be important and worth the expense. These analyses also require consistent sampling procedures across all plots and days (i.e. soil sampling depth).

One limitation of small scale research plots is finding equipment to apply the treatments. We apply granular products such as seed or fertilizer with a very complex piece of equipment; a mason jar with holes drilled into the top. We weigh out the amount of product to apply over a plot, put it in the shaker jar, and then shake it over the plot until its gone (preferable going over the plot three times before the jar is empty for uniformity). Spray applications can be made with a pump action sprayer outfitted with your favorite spray nozzle and calibrated to your walking speed. We step to the beat of a metronome set to a comfortable walking speed to insure a uniform walking speed like in a marching band. The other option is to make plots larger enough in size to use traditional equipment such as a topdresser or aerator.

Setting Up the Experiment in the Field

First you need to select a plot design or pattern and decide on the size of the plots. There are three commonly used plot designs you may see in a research report: completely randomized design, randomized complete block design, and a split plot design (Fig. 1). A completely randomized design (CRD) is just like it sounds. All the plots and their replicates are completely randomized (Fig. 1A). The next design, a randomized complete block design (RCBD), has all the treatments in a line or block. The total number of blocks represents the total number of replicates. In Figure 1B there are three different treatments in a row (represented by different colors) and three replicate rows or blocks. Notice that each row contains all three treatments (colors). The last design is a split plot design (Fig. 1C). In this design the treatments within a block are split down the middle and one half gets treated differently than the other half. These are convenient for studies that have different mowing heights or receive topdressing rates. In Figure 1C you'll notice that the whole plot gets treated with one of three treatments (different color) but those plots are split down the middle to receive the other factor (i.e. lower mowed height down the light shaded colors compared to the brighter colors).

To lay out the plots we use a surveyors tape, marking flags, and landscape paint. To keep the plots square we rely on the Pythagorean Theorem ($a2 + b2 = c2$). In figure 1A for example, the individual plots are eight feet long and six feet wide. The total plot area would be 24 x 18 feet. To make sure the overall plot area is square, the diagonal corner to corner length needs be 30 feet ($\sqrt{(242+182)} = 30$). Having square plots make them look professional, and more importantly is essential to make sure the correct amount of product is being applied to the plot area. It may seem like extra work but it is worth it. After the plot area is square, flag of the corners of the individual plots. Once those flags look square paint dots at all the corners. Placing metal stakes in the four corners of the plot area can be helpful in high mown grass because they can be located with a metal detector if dots are removed during mowing. It also helps with treatment applications and data collection to assign the plots numbers and create a rough sketch of the plots the direction of north on the map. Trust me it is very easy to forget which treatment is which a week or two after application. Your plot map is your guide.

Data Collection and Analysis

It is up to you how often data needs to be collected. Generally you want to collect data frequently enough to record changes but not too frequently that it is a waste of time. Most field researchers take ratings weekly or biweekly while more expensive tests like tissue testing occur monthly or seasonally. Again the frequency is a function of the study. We collected clippings as often as five days a week for the Primo Maxx GDD studies of my M.S. Those studies required frequent data collection because we wanted to see when clipping yield transitioned from the suppression to rebound growth phase. Be sure that all data you generate is recorded somehow for future analysis. A simple way to record data is to make many copies of the plot map and recorded the ratings right on the map for that date.

Collecting grass clippings can be a lot of work but is used to measure how the grass is affected by fertilizer or plant growth regulators.

Data analysis is the portion of the research process that typically requires complicated and expensive statistical software. However, common programs such as Microsoft Excel can be used to do simple stats (i.e. calculate averages and compare treatments). Figure 2 has hypothetical data from the 'MossX' wetting agent study described above. In this example there is a color coded plot map and ratings of turfgrass visual quality and percent moss cover for a particular day. The ratings from each replicate of a particular treatment were first organized into columns. The 'average' function can then be used to calculate the mean visual quality or percent moss cover for each treatment. To use this function, select the cell where you want the average to be generated, type '=average(', and select the cells you want to average.

The last step of the data analysis is to compare the averages. From the 'MossX' experiment we see that quality of the non-treated turfgrass was 7.2 and the low 'MossX' rate with the wetting agent is 6.7. We can use a statistical test called Student's t-Tests to compare two treatments based on a calculated p-value. The p-value is basically the probability that the treatments are actually the same. The greater the p-value the greater the chance, or probability, that two treatments are the same. In science we use a cutoff p-value of 0.05 to decide if two treatments are the same or not. If the p-value is smaller than 0.05, then treatments ruled to be are significantly different (5% or less chance of being wrong and they the treatments are the same). You may decide that a p-value of 0.25 is good enough for you (25% chance that the two treatments are the same).

Excel can calculate the p-value of two treatment by typing '=ttest(select the cells from one treatment, select cells from another treatment,2,2)'. For the 'MossX' example the excel code is '=TTEST(B12:B14,E12:E14,2,2)'. The p-value is 0.101 so the non-treated control is statistically similar to the low 'MossX' rate with a wetting agent despite a slightly lower quality rating. Alternatively a p-value of 0.101 means there is only a 89.9% probability that the treatments are different which isn't conclusive enough for most scientific journal but may be conclusive enough for you. You can use the t test function in Excel to compare other treatments of interest. The visual quality of the high 'MossX' with wetting agent (4.2) is much different than the quality of the non-treated control (7.2) with a very small p-value of 0.003. This means that there is a 0.3% chance that both treatments have the same quality. These t-tests require replication to function. By having replicated treatments and non-treated control you can use basic statistics to make assumptions about how well a product or practice works (or doesn't work). Without replication and controls it is impossible to know what is happening because day to day fluctuation can be so extreme in turfgrass and have nothing to do with the treatments you are studying.

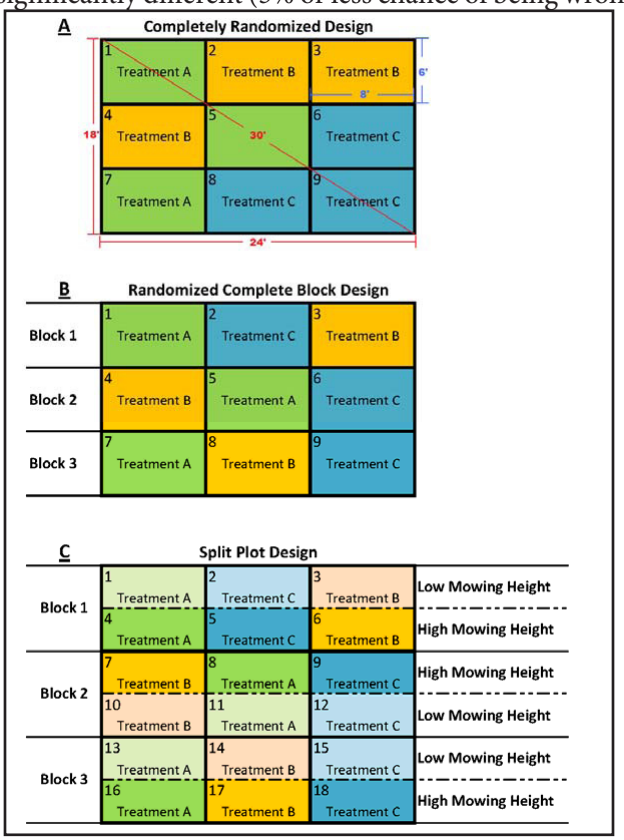


Figure 1.
Different experimental design patterns. A) Completely randomized with three treatments and three replicates. The individual plots are 8 x 6 ft and the total plot area is 24 x 18 ft. To make sure the plots are square the diagonal distance is measured and has to equal 30 ft. B) A randomized complete block design has all treatments in a line called a block. Each block represents one replicate. C) A split plot design is like a randomized complete block design except that the plots are split in half to test another factor. In this example mowing height is the additional factor within each plot

Conclusion

Designing and conducting a turfgrass field experiment doesn't have to be complicated or even too time consuming. Some thought needs to go into the design and analysis but the data collection can be quick. I really believe site specific field research can be very helpful to you and your facility. Every place is different and turfgrass researchers cannot evaluate every possible management practice. Having prior experience with a product or practice can provide piece of mind and help to justify the costs and benefits associated with its utilization at your facility. I've included some easy projects that you can try yourself. Good luck with your research endeavors!

Herbicide Rates and Efficacy Evaluations

Find an area with a uniform distribution of a problematic weed at your facility. For the treatments try different rates, products, or even re-application frequencies. Remember to replicate and randomize the treatments. Then rate turfgrass quality, turfgrass phytotoxicity, and percent weed cover over a period of time to find the best strategy for you situation.

Fungicide Rate and Efficacy Evaluations

Apply different fungicides alone or in various combinations to a nursery green or problematic area of a fairway to observe disease development following application. Remember to have a non-treated control and replicates for comparison. Some common ratings include disease severity or percent disease cover, and visual turfgrass quality

Grass Variety Evaluations

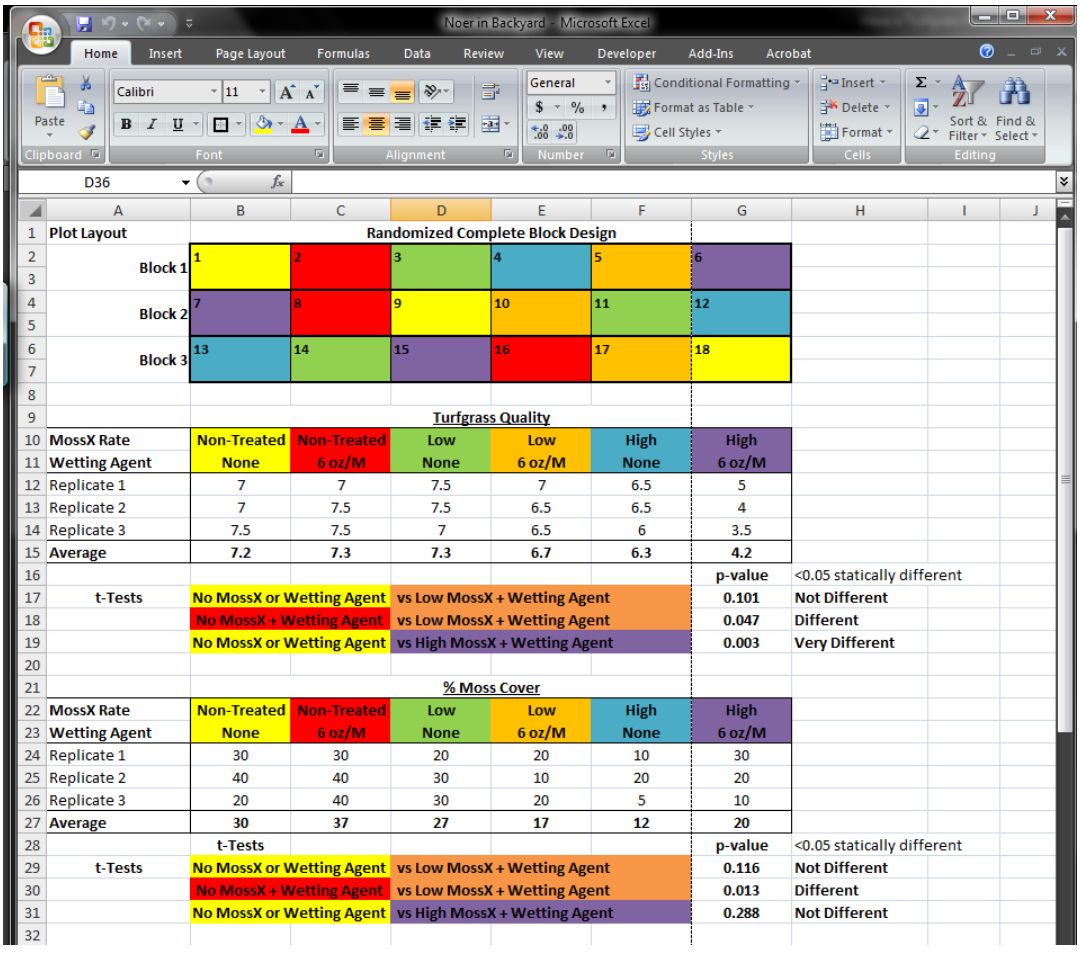
Obtain sample seed of different grass varieties and plant them in replicated grids. Include an older variety or a predominate variety at your facility for comparison. You can apply the seed with a drop spreader or masons jar shaker. Some of the ratings you could do include percent establishment, quality, color, spring green up, and disease or drought susceptibility if you withheld fungicide or irrigation treatments.

Wetting Agent Evaluations

Wetting agents, like plant growth regulators, are confusing because it is difficult to tell how well they are working. For an experiment apply different wetting agents to plots on a nursery green or other problematic area. Then reduce or eliminate irrigation and rate turfgrass quality and localized dry spot development. If you have a TDR soil moisture probe, simply measure the water content within a plot or take several measurements within a plot to analyze the distribution of the water within the plot.

Fertilizer Evaluations

Test different fertilizer products and biostimulants. Simple ratings include turfgrass quality, color, clipping yield, and tissue nutrient analysis. Again, remember to replicate the treatments and non-treated control plots. The control in a nitrogen evaluation is particularly important to account for soil nitrogen mineralization that can occur and possibly lead to incorrect conclusions. And try different nutrients like calcium and potassium fertilization to see how important they are to your foliar fertility program.



	A	B	C	D	E	F	G	H
1	Plot Layout			Randomized Complete Block Design				
2	Block 1	1	2	3	4	5	6	
3								
4	Block 2	7	8	9	10	11	12	
5								
6	Block 3	13	14	15	16	17	18	
7								
8								
9				Turfgrass Quality				
10	MossX Rate	Non-Treated	Non-Treated	Low	Low	High	High	
11	Wetting Agent	None	6 oz/M	None	6 oz/M	None	6 oz/M	
12	Replicate 1	7	7	7.5	7	6.5	5	
13	Replicate 2	7	7.5	7.5	6.5	6.5	4	
14	Replicate 3	7.5	7.5	7	6.5	6	3.5	
15	Average	7.2	7.3	7.3	6.7	6.3	4.2	
16							p-value	<0.05 statically different
17	t-Tests	No MossX or Wetting Agent		vs Low MossX + Wetting Agent			0.101	Not Different
18		No MossX + Wetting Agent		vs Low MossX + Wetting Agent			0.047	Different
19		No MossX or Wetting Agent		vs High MossX + Wetting Agent			0.003	Very Different
20								
21				% Moss Cover				
22	MossX Rate	Non-Treated	Non-Treated	Low	Low	High	High	
23	Wetting Agent	None	6 oz/M	None	6 oz/M	None	6 oz/M	
24	Replicate 1	30	30	20	20	10	30	
25	Replicate 2	40	40	30	10	20	20	
26	Replicate 3	20	40	30	20	5	10	
27	Average	30	37	27	17	12	20	
28		t-Tests					p-value	<0.05 statically different
29	t-Tests	No MossX or Wetting Agent		vs Low MossX + Wetting Agent			0.116	Not Different
30		No MossX + Wetting Agent		vs Low MossX + Wetting Agent			0.013	Different
31		No MossX or Wetting Agent		vs High MossX + Wetting Agent			0.288	Not Different
32								

Figure 2. An example Excel spreadsheet of the 'MossX' wetting agent study. The top figure is the plot map showing the location of each of the six treatments. The tables below are the visual quality data and percent moss cover ratings for a particular day. Average was calculated below the table for each treatment. Selected treatments were compared with the t-test function in Excel to calculate a p-value. A p-value less than 0.05 was deemed statistically different.